Antivibration Element

Background of the Invention

An antivibration element is disclosed in United States

5   Patent 5,368,107 which includes a coil spring. The coil spring

is fixed at its ends on an elastic guide element by means of

mounts. The damping action of this antivibration element is the

same for every load condition because of the linear

characteristic line. For reasons cf vibration, it is desirable

10   that the antivibration element have a low spring constant in the

unloaded state; whereas, under load, the element should be as

stiff as possible, that is, the spring constant should be as high

as possible.

Summary of the Invention

15   It is an object of the invention to provide an antivibration

element of the kind described above wherein the entire

antivibration element has a different spring constant for

different states of loading.

The antivibration element of the invention includes: a coil

20   spring having an end section and a transition section extending

from the end section; a guide member; the end section fixed to

the guide member; and, the transition section being guided on the

guide member with play.

The coil spring is fixed at its end sections. The

25   transition section borders on the end section in a direction

toward the center portion of the coil spring. In the unloaded

state, the transition section has play with respect to the guide.

The play can be radial and/or axial. The turns of the transition

section thereby contribute to the spring action. With the

30   deformation of the spring under load, the play is overcome and

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the turns are at least partially in contact engagement against

the guide in the transition section and therefore no longer

contribute to the spring action. In this way, the spring

stiffness of the coil spring is increased. With different

5   configurations of the guide, a load-dependent damping action can

be achieved which is adapted to the particular application. The

adaptation of the spring stiffness can take place in dependence

upon direction, for example, in that different play is provided

in the axial and radial directions.

10   It is practical to fix the end section to the guide so that

it is form tight thereon. The end section can extend over a 3/4

turn to 2 turns and extends especially approximately over 1-1/4

turns of the coil spring. In this way, the coil spring is

adequately fixed. At the same time, the number of spring-acting

15   turns is comparatively large for a pregiven spring length. The

transition section advantageously extends over approximately 1

to 4 turns. The spring stiffness can be adequately varied in

this way. An adequate movability of the spring in the non-guided

region is simultaneously ensured.

20   In order to obtain different spring stiffnesses in different

directions, the two ends of the coil spring are twisted toward

each other, especially, approximately by a half turn. In order

to make possible an adequate variation of the spring constant,

the coil spring is guided at both end sections with play in the

25   region of the transition section.

The guide is formed on a plug projecting into the interior

of the coil spring and this plug has a receptacle for an

attachment means. However, a guide on the outer side of the coil

spring can be practical. The guide is advantageously configured

30   as a spirally-shaped slot wherein the turns of the coil spring

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are guided. The assembly of the guide in the coil spring can be

effected in this way by a simple threaded engaging. A

spirally-shaped slot of this kind is easy to produce with low

manufacturing tolerances. The distance of the base of the slot

5   to the longitudinal center axis of the coil spring decreases in

the transition section with increasing distance from the end

section. The play in the transition section therefore increases

in a direction toward the center portion of the coil spring.

With increasing load and with the increasing deformation

10   resulting therefrom, more turns come continuously into contact

engagement against the guide so that the spring constant

increases in correspondence to the reduction of the spacing. In

this way, a good guide characteristic of the work apparatus is

achieved.

15   The slot advantageously has a trapezoidally-shaped cross

section which is easy to produce. The flanks of the slot and the

longitudinal center axis of the coil spring conjointly form an

angle which is less than 90°. This angle especially amounts to

approximately 30° to 80°. With increasing deformation of the

20   coil spring, the play therefore becomes less in axial direction.

It can, however, be practical that the slot have the shape of a

segment of a circle when viewed in cross section. In this way,

another course of the spring stiffness is achieved. With the

variation of the slot cross section, different courses of spring

25   stiffness can be realized in dependence upon the deformation path

and the deformation direction.

Brief Description of the Drawings

The invention will now be described with reference to the

drawings wherein:

30   FIG. 1 is a perspective view of the antivibration element of

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the invention in the unloaded state;

FIG. 2 is a longitudinal section taken through the antivibration element of FIG. 1;

FIG. 3 is a schematic showing a guide of the antivibration

5   element of FIG. 2 for an unloaded coil spring;

FIG. 4 is a schematic of the guide element of FIG. 3 with the coil spring under load;

FIG. 5 is a perspective view of the antivibration element of FIG. 1 with a single axis deformation;

10   FIG. 6 is a section view taken through the antivibration element of FIG. 5;

FIG. 7 is a schematic of the antivibration element of FIG. 1 under a two-axis deformation;

FIG. 8 is a section view taken through the antivibration

15   element of FIG. 7;

FIG. 9 is a perspective view of the antivibration element of FIG. 1 for a deformation and compressive action in the longitudinal direction;

FIG. 10 is a section view through the antivibration element

20   of FIG. 9;

FIG. 11 is a perspective view of the antivibration element of FIG. 1 during deformation and expansion;

FIG. 12 is a section view taken through the antivibration element of FIG. 11;

25   FIG. 13 is a section view of a plug with a coil spring;

FIG. 14 is a force/displacement diagram for the plug of FIG. 13;

FIG. 15 shows the spring stiffness plotted as a function of the deformation for the plug of FIG. 13; and,

30   FIGS. 16 to 23 show variations for the guide in section.

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Description of the Preferred Embodiments of the Invention

The antivibration element 1 is shown in a perspective view in FIG. 1 and includes a coil spring 2 guided at its two ends on respective plugs (3, 4). As shown in FIG. 2, the plugs (3, 4)

5   extend into the interior of the coil spring 2. Each plug (3, 4) includes a spirally-shaped slot (9, 10) which forms the guide for the coil spring 2. The coil spring 2 is guided with its end sections (7, 8) form tight in the slots (9, 10), respectively. The end sections (7, 8) extend over a 3/4-turn to two turns and

10   especially over approximately 1 and 1/4-turns of the coil spring 2. The number of turns is measured from the ends 5 and 6 of the coil spring 2 shown in FIG. 1. Transition sections 11 and 12 extend from end sections 7 and 8, respectively and extend over approximately 1 to 4 turns. The coil spring 2 is guided

15   with play in the slots 9 and 10 at the transition sections 11 and 12, respectively.

The slot 9 is configured in the plug 3 and has a trapezoidally-shaped cross section. The slot base 15 runs approximately parallel to the longitudinal axis 13 of the coil

20   spring 2. The flanks 16 and 17 delimit the slot 9 in the direction of the longitudinal axis 13. The flanks 16 and 17 are inclined at an angle α to the longitudinal axis 13. Correspondingly, the slot 10, which is formed in plug 4, has a slot base 18 which runs parallel to the longitudinal axis 13.

25   The slot 10 also has flanks 19 and 20 which are inclined at an angle α to the longitudinal axis 13. The angle α is less than 90° and is especially approximately 30° to 80°. The slot bases (15, 18) each have a play (b) to the coil spring 2. The play (b) increases with increasing distance from the end

30   sections (7, 8). As shown in FIG. 2, the play (b) increases in

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the course of a half turn of the coil spring 2 to the play (b').
As shown in FIG. 3, the distance (a) of the slot base 15 to the
longitudinal axis 13 of the coil spring decreases to the
distance a'. The line 23 is formed by the course of the base 15

5   of the slot in the transition section 1 and this line thereby
runs conically in a direction toward the center of the coil
spring 2.

In the axial direction, the coil spring 2 has play (c) to
the flank 16 and has play (d) to flank 17. Accordingly, the coil

10   spring 2 has play relative to the plug 3 in radial and axial
direction in the transition section 11. The coil spring 2 has
the corresponding play in the transition section 12 to the
plug 4. The plugs 3 and 4 can, however, be configured to be
different so that the transition sections 11 and 12 have

15   different play to the plugs 3 and 4 in the axial and/or radial
directions.

In a deformation of the coil spring 2 as shown in FIG. 4,
the spacing of the coil spring 2 to the guide 9 reduces on the
bending outer end 21. As shown in FIG. 4, the coil spring 2 lies

20   against the slot base 15. The turn which is in contact
engagement does not contribute any longer to the spring action.
The number of spring-acting turns is reduced and therefore the
spring stiffness of the coil spring 2 is increased. At the
bending end 22, the play in the slot base 15 increases to the

25   play b". The coil spring 2 lies against the first flank 16 while
the play d' to the second flank 17 is increased relative to the
unloaded state.

For fixing the coil spring, for example, in a portable
handheld work apparatus, one end of the coil spring is fixed to a

30   first housing part and a second end of the coil spring is fixed

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to a second housing part. For fixing the coil spring to the
housing parts (not shown), the plugs (3, 4) each have
longitudinal bores 14 which function to accommodate an attachment
means. This means can, for example, be a pin projecting into the

5   longitudinal bore 14. However, it can be practical to provide an
internal thread on the inner bore 14 and to threadably engage a
screw into a plug 3 or 4 for fixing. The first housing part can,
for example, be a component connected to the drive motor of the
work apparatus while the second housing component can be

10   connected to the handle of the work apparatus.

        In FIGS. 5 and 6, the antivibration element 1 is deformed
perpendicularly to the longitudinal center axis 24 of the plug 3
and the longitudinal center axis 25 of plug 4. In FIGS. 5 and 6,
the deformation is 7 mm in the direction of the X-axis. The

15   longitudinal center axis 25 of the plug 4 is therefore displaced
by 7 mm in the direction of the X-axis with respect to the
longitudinal center axis 24 of the plug 3. As shown in FIG. 6,
the Z-axis runs in the direction of the longitudinal center
axes 24 and 25 and the Y-axis extends perpendicularly into the

20   plane of the drawing. With the deformation, the distance of the
coil spring 2 to the plugs 3 and 4 in the slot base is increased
by the deformation on the bending inner side 22. The coil
spring 2 lies against the flank 16 of the slot 9 while play is
present with respect to flank 17. The same applies for the

25   bending inner side 22 and the plug 4. The coil spring 21 lies
against corresponding plugs 3 and 4 on the bending outer side 21.
The number of spring-acting turns of the coil spring 2 is thereby
reduced and the spring stiffness is increased compared to the
unloaded state.

30   In FIGS. 7 and 8, the antivibration element 1 is shown for a

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deformation of 7 mm in the X-direction and, in the Y-direction, of -7 mm. The longitudinal center axis 24 of the plug 3 includes a spacing of 7 mm with respect to the longitudinal center axis 25 of the plug 4 in the X-direction as well as in the Y-direction.

5   Here too, the turns of the bending outer side 21 lie on each of the plugs 3 and 4 so that the number of spring-acting turns is reduced relative to the unloaded state and the spring constant is increased.

In FIGS. 9 and 10, the antivibration element 1 is, in
10   addition to the deformation in the X-direction by 7 mm and the deformation in the Y-direction by -7 mm, shortened by 5 mm in the direction of the Z-axis and, in FIGS. 11 and 12, the antivibration element 1 is lengthened additionally by 5 mm. As shown in FIG. 10, the spring constant of the coil spring 2 is
15   further reduced when there is an intense deformation and shortening of the antivibration element. This is achieved in that the turns of the coil spring 2 in a region 54 of the coil spring bordering on the transition section 11 are in contact engagement with each other. The turns lie, as above, against the
20   plugs 3 and 4. In contrast to this, in the extension of the antivibration element 1 shown in FIGS. 11 and 12, the turns of the coil spring 2 already have a radial play (b) and an axial play (c) and (d) in the transition sections 11 and 12. Accordingly, in the deformation state shown in FIGS. 11 and 12,
25   the spring constant of the coil spring 2 is less than in the deformation state shown in FIGS. 9 and 10.

In FIG. 13, a plug 26 having a slot 27 is shown wherein a coil spring 2 is guided. The slot 27 has an approximately circular-shaped cross section which has a play (e) to the coil
30   spring 2 in the axial and radial directions in a transition

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section 11 of the coil spring 2. In FIG. 14, the
force/displacement diagram for an antivibration element having a
plug 26 is shown and, in FIG. 15, the course of the spring
constant C is shown plotted as a function of displacement (s).

5   In region 30, the force F to displacement (s) runs as indicated
by line 28 approximately constant. In this region of the
deformation, the turns in the transition regions 11 and 12 of the
coil spring are movable relative to the guide and therefore have
a play to the slot 27. In the bordering region 32 and starting

10   from the end sections 7 and 8, the turns of the coil spring 2 lie
more and more against the guide in the transition regions 11
and 12. The force, which is necessary for deforming the coil
spring 2, increases overproportionally in the region 32. The
course of the spring constant C is shown by line 29 in FIG. 15.

15   As shown in FIG. 15, the spring constant C runs approximately
constant in the region 31 which corresponds to the region 30 in
FIG. 14. With increasing deformation, the spring constant C
increases in the regions 33 which correspond to the regions 32 in
FIG. 14. If all turns lie against the guide in the transition

20   region, then the spring constant C remains constant in the
regions 35. In the corresponding region 34 of the line 28, the
force F, which is necessary for deformation, remains proportional
to the deformation displacement (s).

The slot, in which the coil spring 2 is guided in the

25   transition region, can have the most different cross-sectional
forms adapted to the particular application. The slot 36, which
is shown in cross section in FIG. 16, has in its upper region 55
flanks 56 and 57, which run perpendicular to the longitudinal
axis 13 of the coil spring 2. In a lower region 58 extending

30   directly therefrom, the slot 36 has a circular-shaped cross

section. With slight deformation, the coil spring 2 is in the

upper region 55 of the slot 36 and has axial play (f) to the

flanks 56 and 57. For a deformation of the coil spring 2 and for

a reduction of the radial play caused thereby, the axial play (f)

5   reduces to a value f' as soon as the coil spring 2 is in the

lower region 58. The spring stiffness C increases greatly

thereby with deformation of the coil spring 2.

In FIG. 17, a slot 37 is shown having a trapezoidally-shaped

cross section. The flanks 52 and 53 of the slot 37 are inclined

10   relative to the longitudinal axis 13 of the coil spring 2 by an

angle β which corresponds to approximately 45°. With the

variation of the angle β, the increase of the spring stiffness C

can be adjusted when the coil spring 2 is deformed.

In FIG. 18, a slot 38 is shown which, in an upper region 59,

15   has flanks 61 and 62 which run parallel to each other and which

run perpendicular to the longitudinal axis 13 of the coil

spring 2. In a lower region 60, the slot 38 is configured to

have a circular-arc shape. The coil spring 2 is guided in the

slot 38 with a radial play but without axial play.

20   FIG. 19 shows a slot 39 having an approximately quadratic

cross section. The coil spring 2 has a play (g) to the flanks 63

and 64 and to the slot base 65. The distance between spring and

slot can be equal in all directions or it can be different

depending upon direction. Rectangular-shaped slot cross sections

25   can also be advantageous.

In FIG. 20, a slot 40 is shown which has only a slight axial

play in an upper region 66. The flanks of the slot 40 run

perpendicular to the longitudinal axis of the coil spring 2 in

this region and parallel to each other. The coil spring 2 is

30   guided tightly between the flanks in axial direction. In a lower

region 67, the slot 40 expands in the axial direction so that, for increasing deformation, the play in the axial direction increases whereas, the play in the radial direction decreases because of the reduced spacing.

FIG. 21 shows a slot 41 which, in an upper region 68, has a large axial play and, in a center region 69, very slight axial play and, in a lower region 70, has large axial play. For this purpose, in the center region 69, the slot 41 is constricted. The spring stiffness does not increase continuously but reduces again as soon as the coil spring 2 is in the lower region 70.

In the slot 42 shown in FIG. 22, the coil spring 2 is tightly guided in an upper region 71 in axial direction. Axial play is not present in the upper region 71. In a lower region 72, the slot 42 first widens in order to then again narrow. The slot 42 has an approximately hexagonally-shaped cross section in the lower region 72.

The slot 43 shown in FIG. 23 has an approximately circular-arc shaped cross section. The cross section of the slot 43 can, however, also be configured to be elliptical. Depending upon the desired change of the spring constant C and the permitted maximum deformation, other cross sections of the guide can be practical. The cross section can be adapted to the wanted progression of the characteristic line of the antivibration element. Instead of providing a plug for a guide, the coil spring 2 can also be guided on its periphery. The progression of the antivibration element can likewise be adjusted via the conicity of the slot spiral. A direction-dependent progression can be achieved in that the ends 5 and 6 of the coil spring are rotated relative to each other. Also, a depth, which is different in different directions, and/or a wide slot spiral

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can be advantageous.

   It is understood that the foregoing description is that of the preferred embodiments of the invention and that various changes and modifications may be made thereto without departing

5   from the spirit and scope of the invention as defined in the appended claims.